Development of New Zn-Ni-Cd Coatings from Alkaline Solutions

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Introduction

Cd has been used extensively as a corrosion resistant coating owing to its excellent corrosion resistance and engineering attributes.[1] However, its toxicity has required the alternate coating. Zn-Ni alloy coatings have been suggested as replacement for Cd coating. Due to the high Zn content in the deposit, these alloys are more negative than Cd and hence dissolve rapidly in corrosive environments. Besides corrosion problem, hydrogen embrittlement is a serious concern that can limit the usage of various metals in different aqueous environments.[2] Hydrogen permeation can be inhibited by changing the kinetics of hydrogen evolution reaction, by increasing the hydrogen recombination constant or by depositing nanostructured barrier films.[3,4]

In this work, Zn-Ni-Cd coating was developed using electrodeposition from alkalic bath and electroless deposition processes. The objective of this study is to determine the corrosion and permeation characteristics of these coatings deposited on steel substrates. In house developed mathematical model for characterization of hydrogen permeation into metal and alloys under corroding conditions was used to quantitatively estimate various kinetic parameters associated with hydrogen permeation.

Experimental

Cd and Zn-Ni was deposited from commercial bath for the reference to evaluate the corrosion and hydrogen permeation resistance of Zn-Ni-Cd coatings on steel. Zn-Ni-Cd was deposited potentiostatically using alkalic bath containing $ZnSO_4$, $NiSO_4$, $CdSO_4$ and NH_4OH. Tafel, linear polarization were carried out to study corrosion characterization. The Devanathan-Stachurski type permeation cell was used to study the hydrogen permeation characteristics. In the cathode part hydrogen evolution reaction takes place on the surface of deposited film tested in the solution of 0.5M Na_2SO_4 and 0.5M H_3BO_3 at pH 7 with respect to the overpotential applied.

Results and Discussion

Cd content in deposit was controlled by bath conditions such as pH, concentration of Cd in bath, applied potential and stirring speed. In the alkalic bath, Cd content could be easily reduced and its surface morphology was improved. Cd depends on strongly the mass transfer and dominated the deposition even though its concentration in bath was small compared to Zn and Ni which are controlled by kinetic parameters. Linear polarizations of Zn-Ni-Cd (ratio of 50/28/20) from alkalic bath and Cd, Zn-Ni coating using commercial bath was shown in Figure 1. According to this data, corrosions resistance of Zn-Ni-Cd coating developed in our laboratory was higher than commercial Cd and Zn-Ni coatings.

In the case of hydrogen permeation test, as shown in Figure 2, the permeation current density of Zn-Ni-Cd coating was much smaller when compared to commercial coatings. Permeation model[2] under corroding conditions was used to analyze kinetic parameters. The hydrogen entry efficiency defined as the ratio of the permeation current density and the cathodic current density is plotted as a function of the overpotential. The results indicated that Zn-Ni-Cd inhibited completely the hydrogen entry in steel. The observed effects are due to the suppression of the hydrogen absorption by the deposited monolayers, and due to the kinetic limitations of the hydrogen discharge reaction.

Acknowledgments

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References

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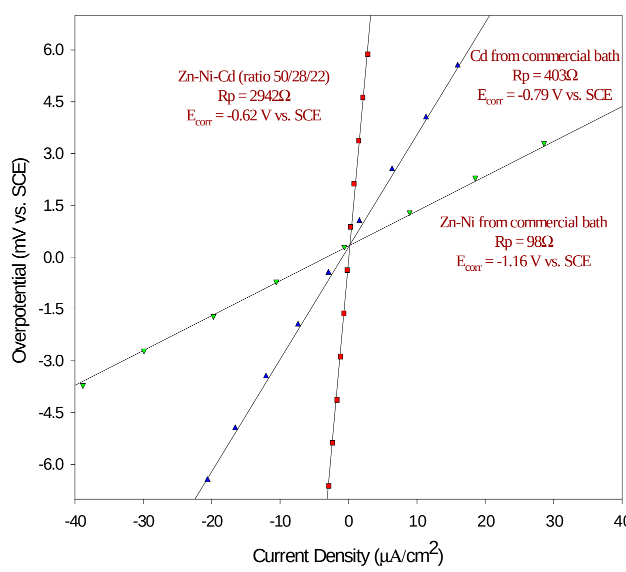

Fig. 1 Linear polarization plots for the Zn-Ni-Cd, Cd and Zn-Ni

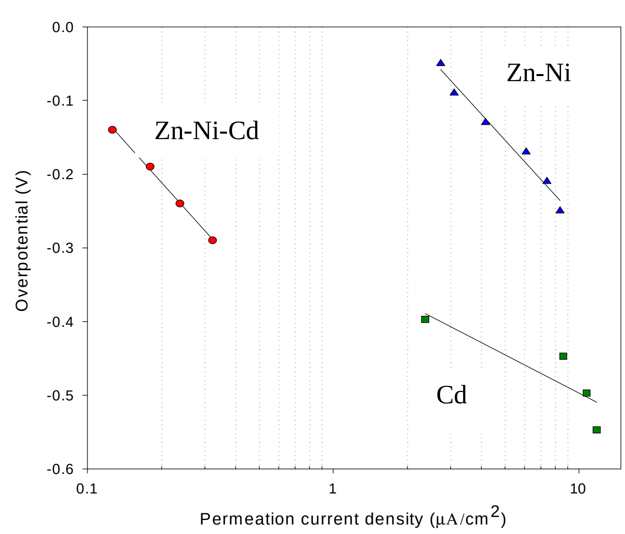

Fig. 2 Plot of permeation current densities as a function of applied overpotentials for different kind of deposited films